FACTORIAL EQUATIONS FOR ATTENTION TESTS

BY

JOHN RICHARD WITTENBORN

B.Ed., Southern Illinois Normal University, 1937

M.S., University of Illinois, 1939

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PSYCHOLOGY IN THE GRADUATE SCHOOL OF THE UNIVERSITY OF ILLINOIS, 1942

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FACTORIAL EQUATIONS FOR ATTENTION TESTS

A. *Plan of Investigation*

This investigation has as a background a series of studies which began in 1914 with Woodrow's monograph on *The Measurement of Attention*[29] and continued through Philip's *Measurement of Attention,*[10] the *Preliminary Report on Spearman-Holzinger Unitary Trait Study*[2] in which some of Philip's tests were employed, and two factorial studies published in 1939 by Woodrow[32, 33] wherein a new factor, tentatively termed Attention, was reported.

In order to investigate and to define more clearly the ability of attention suggested by the studies of Holzinger[2] and of Woodrow,[32, 33] the present study was undertaken. The plan of the present investigation involves two chief steps:

(1) devising new tests of attention; and
(2) analyzing by factor analysis the intercorrelations of a battery of tests which included, in addition to the newly devised tests of attention, tests of certain well established factors.

The primary purpose of the investigation was to determine the factorial composition of the tests devised as tests of attention.

B. *Construction and Selection of Tests*

In constructing the tests a large number of test items or performances were devised which were regarded as equivalent or similar to the performances involved in those tests contributing to the factors tentatively identified by previous investigators as attention factors.[2, 32, 33] Particular consideration was given to the tests of Philip used by Holzinger[2] and Woodrow,[32, 33] as well as to certain other tests used by Woodrow, called Vertical Copying[32] and Directions.[32, 33] In selecting or devising items for the new tests, certain requirements were formulated:

1. The tasks should emphasize following directions and depend upon content to as small a degree as possible.

2. The scores on the tests should depend to a large degree upon a continuous, sustained application of mental effort.
3. The performances should not depend upon exact intellectual status.
4. The tests should not correlate with factors heretofore identified.

In an attempt to devise a performance that would not depend upon exact intel'ectual status, material which was familiar to almost all persons was chosen. Digits and letters of the alphabet were selected as suitably familiar material. Tasks which presumably depend upon directions to a great extent and which also presumably were not dependent upon the exact nature of the material or upon abilities heretofore identified by factor analysis were, after numerous trials, devised as the basis for the tests. To insure that the tests would depend upon a sustained application of effort, the items were presented one at a time and at a rate that allows a minimal time for interpolated activity. The importance of continuous and sustained work was maximized by using tasks in which the response to an ensuing item is in part conditioned by the responses to previous items. Two possible modes of presentation were considered, visual and auditory. After some preliminary investigation, the auditory mode was selected. The determining consideration was mechanical convenience.

Since the primary purpose of the investigation was to determine whether the factorial equations of the prepared tests would involve a factor in addition to any known to be measured by certain other tests in the battery, it was necessary to select for inclusion tests known to be valid measures of certain well established factors. Factors which were suspected as possibly contributing to scores on the prepared tests were number, rote memory, and the visual-spatial factor. Due particularly to the investigations of Thurstone, convenient tests of these abilities were available. Tests 5 and 18 were chosen as tests of the number factor;[18] tests 3 and 14 as tests of the rote memory factor;[18] and 1 and 13 as tests of the visual-spatial factor.[18]

Cancellation tests have been found to contribute to a factor of perception.[1, 20, 32, 33] Since cancellation has long been regarded as a test of attention, two cancellation tests, 6 and 10, and two tests, 2 and 7, that have been employed by Thurstone[20] as tests of the perceptual factor were included in the test battery. In addition, two tests, Otis Directions, 8, and Philip's Alphabet, 15, which were found in previous studies to be measures of a factor of attention,[32, 33] were also included. The Seashore Tonal Memory Test, 4,[13] was included in the battery because of some resemblance to certain of the tests that had been constructed for this study. A final test, 20, syllogisms, was prepared and included in the battery. Tests 9, 11, 12, 16, 17, and 19 are new tests prepared for this study.

C. *Subjects*

The tests were administered to four beginning classes at the Air Corps Technical School at Chanute Field, Rantoul, Illinois, during the Spring of 1940. The men, ranging in age from 18 to 30 years, had completed four years of high school or the equivalent and were selected on the basis of high standing in the Army Alpha for instruction in radio. Complete test data were obtained for 175 men.

D. *The Factor Analysis*

Pearson product-moment coefficients of correlation were calculated between the scores of each test and those of every other test. The table of intercorrelations was subjected to a centroid analysis and although nine centroid factors were extracted, Tucker's criterion as employed by Thurstone[18] was the only evidence indicating that more than seven factors should have been extracted.

A preliminary attempt was made to employ a rotational method which involved an extension of the test vectors.[21] This method was abandoned in favor of the more conventional graphic orthogonal method[17] which in the present study offered the advantage of greater precision in rotation.

The final solution, Table I, was based on an orthogonal

rotation of the first seven centroid factors. These rotated factors were observed to be strikingly similar to those found by the method of extended vectors. The fact that two entirely different rotational procedures yielded the same meaningful factors is considered to be evidence of the validity of the rotation. That the same meaningful rotated factors were yielded in each instance, despite there being eight centroid factors

	P I	A_1 II	M III	A_2 IV	S V	N VI	VII	h^2
1	.112	.074	.257	.168	.699	-.029	.063	.606
2	.428	-.026	.076	.182	.174	.024	.427	.436
3	.155	-.006	.531	.045	-.020	.211	.112	.366
4	-.006	.445	-.057	.146	-.002	-.004	486	.459
5	.132	.193	-.015	.284	.044	.642	.031	.551
6	.516	-.061	.010	.236	.154	.022	-.110	.362
7	.372	.196	.144	.049	.149	.235	.208	.321
8	.239	.297	-.120	.449	.207	.117	.107	.429
9	.092	-.023	-.018	.535	.068	.331	.370	.547
10	.682	.097	.191	.185	.077	.192	.022	.568
11	.002	.038	.042	.727	.083	.211	.165	.610
12	.018	.233	.197	.445	.135	.122	.173	.354
13	.037	.147	.128	.089	.743	-.042	.124	.616
14	.062	.092	.562	.107	.050	.276	-.077	.424
15	.033	.499	-.021	.262	-.011	.319	.128	.437
16	.014	-.070	.057	.488	-.041	.138	.215	.313
17	.029	.042	.062	.660	.050	.029	.022	.446
18	.155	-.119	.003	.214	.120	.758	.165	.700
19	.245	.141	-.068	.517	.128	-.005	-.012	.368
20	.030	.392	.031	.307	-.024	-.049	-.098	.262

involved in the first method and seven involved in the second, may be considered as further evidence that seven centroid factors account for ssentially all of the common factor variance.

The rotated Factors III, V, and VI were immediately recognized as Thurstone's memory, space, and number factors.[18] The tests employed in identifying these factors were tests used by Thurstone in his investigations and since the

factors are generally known, no interpretation or description of these factors is needed. Factor I, which was heavily loaded with perception tests, particularly those of the cancellation type, was interpreted as a factor of perception.

Two of the rotated factors, II and VII, were considered to have no psychological meaning and no attempt was made to interpret them.

Factor IV is the factor of attention. It was to establish the existence and to define the nature of this factor that he present study was undertaken. The tests which are highly saturated with Factor IV, tests 8, 9, 11, 12, 16, 17, and 19, appear to depend upon the application of sustained, concentrated effort. The factor common to these tests cannot be explained in terms of the sensory mode of presentation. Tests 9, 11, 12, 16, 17, and 19 are presented by means of sound, but test 8 is Otis Directions and is presented as a printed sheet. On the other hand, tests 4 and 15, though also presented by means of sound, show no significant loading with Factor IV. There is evidence, furthermore, that the factor does not depend upon content. Test 8, Otis Directions, involves printed words and other types of symbols; test 12 makes use of digits and letter combinations; and tests 17 and 11 call for responses to letters of the alphabet and digits respectively.

Factor IV is similar to, but not necessarily identical with, Woodrow's factor of attention.[32, 33] Particular evidence for this similarity is the fact that the Otis Directions Test, number 10 in the present study, contributes to the factor of attention in each of his studies, as well as to Factor IV of the present study. General evidence of the similarity is the fact that the writer's concept of the nature of Woodrow's factor determined to a large degree the type of tests constructed for the present investigation.

E. *Conclusions*

1. A single factor, which has been termed attention, accounted for the common factor variance of tests which were constructed to involve a high degree of sustained effort.
2. The factor is independent of content. The two best mea-

sures of the factor were different in content; test 11 involves digits alone and test 17 involves letters only.

3. There is no evidence that the factor depends upon the mode of presentation. While most of the tests contributing to the attention factor were presented in an auditory manner, by means of phonograph, test 8, which showed a significant loading with the factor, was presented in a visual manner. On the other hand, tests 4 and 15, which were also auditory, showed no significant correlations with this factor.
4. The fact that the two separate rotational procedures yielded essentially the same factors is evidence for the uniqueness and validity of the rotations.
5. Three Thurstone factors, memory, space, and number, were clearly defined in the orthogonally rotated factor matrix.
6. A perceptual factor heavily loaded with cancellation tests was also defined in the rotated factor matrix.
7. Two factors, II and VII, showed no important correlations with the tests and no attempt was made to give them a meaningful psychological interpretation.

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VITA

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